METHODS FOR SETTING HATCHERY PRODUCED OYSTER LARVAE

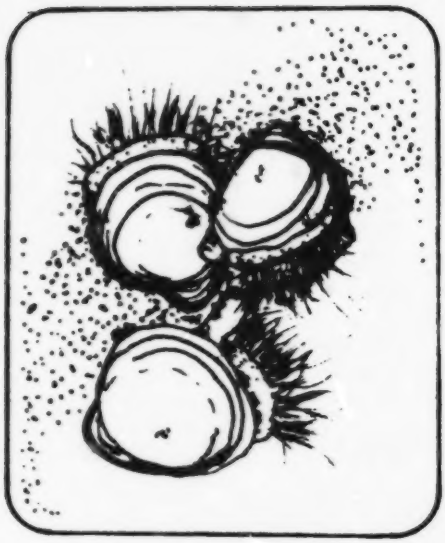
PREPARED BY

GORDON AND BRUCE JONES

INNOVATIVE AQUACULTURE PRODUCTS, LTD.

SKERRY BAY, LASQUETI ISLAND, B.C.

CANADA



INFORMATION REPORT No. 4.

PREPARED FOR

MARINE RESOURCES BRANCH

MINISTRY OF ENVIRONMENT

PROVINCE OF BRITISH COLUMBIA

MARCH, 1982

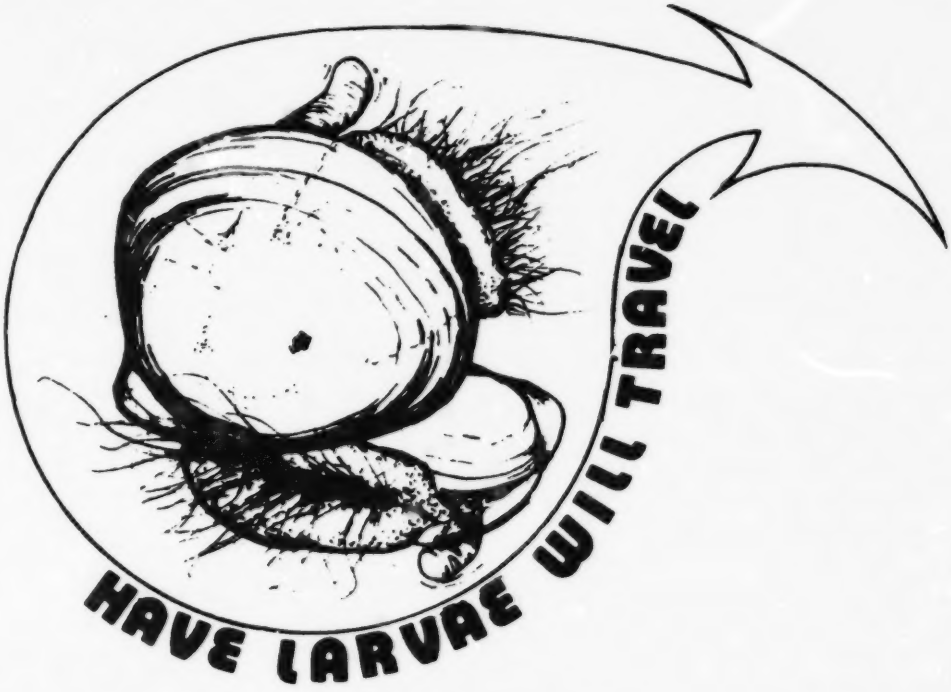
Canadian Cataloguing in Publication Data
Jones, Gordon, 1951-
Methods for setting hatchery produced oyster larvae

(Information report, ISSN 0229-8120 ; no. 4)

"Innovative Aquaculture Products, Ltd."
Bibliography: p.
ISBN 0-7719-8971-7

1. Oyster-culture - British Columbia. 2. Oyster-culture - Pacific coast (United States and Canada) I. Jones, Bruce, 1947- . II. British Columbia. Marine Resources Branch. III. Innovative Aquaculture Products Ltd. IV. Title. V. Series: Information report (British Columbia. Marine Resources Branch) ; no. 4.

SH367.C3J66 639.'411'09711 C82-092178-5


HAVE LARVAE WILL TRAVEL

PREFACE

This report on the setting of eyed oyster larvae is designed to provide the prospective user of oyster hatchery larvae with information concerning the present status of the field and details on how to set up their own systems.

Considerable information has been published on hatchery techniques and oyster biology; however, little attention has been given to the setting of oysters under commericial situations. We felt that this quickly developing seed production method needed to be documented for British Columbia oyster growers and seed producers who were looking for more reliable sources of oyster seed.

We wish to express our gratitude for the cooperation that we received from the people

we interviewed during the preparation of this report. The information that they magnanimously passed along to us for publication could be considered by some as proprietary since our questions dealt with subjects that the companies had spent considerable time and money researching.

We are also indebted to the British Columbia Oyster Growers Association for their unanimous endorsement of this project and to the Marine Resources Branch for their cooperation and funding.

CONTENTS

PAGE

PREFACE 1

CONTENTS 3

BACKGROUND 5

MAP OF OPERATIONS 9

INTRODUCTION 11

GENERAL HATCHERY AND SETTING METHODS 13

SURVEY OF DESIGNS, METHODS AND RESULTS.....16

TAYLOR UNITED INC. 17

OLYMPIA OYSTER CO. 22

WIEGARDT AND SONS INC. 26

SEA FARMS INC. 31

LUMMI INDIAN TRIBAL HATCHERY 33

HAYES OYSTER CO. 37

INDIAN BAY OYSTER FARMS 39

OREGON OYSTER CO. 40

NEWPORT-PACIFIC OYSTERS 42

INNOVATIVE AQUACULTURE PRODUCTS, LTD. ..44

SUMMARY OF SETTING FACILITIES 50

RECOMMENDATIONS FOR SETTING OPERATIONS 51

SETTING TANK DESIGN AND CONSTRUCTION ...51

PREPARATION OF CULTCH 56

SETTING TANK ENVIRONMENTAL PARAMETERS ..57

REFERENCES 60

BACKGROUND

In Canada and the United States oyster production has been waning for the past 80 years. This has been caused mostly by pollution, siltation, natural disasters, disease and predation. In British Columbia, Washington, Oregon and California the wholesale value has steadily increased (dispite the decline in production) to a current value of approximately 30 million dollars annually.

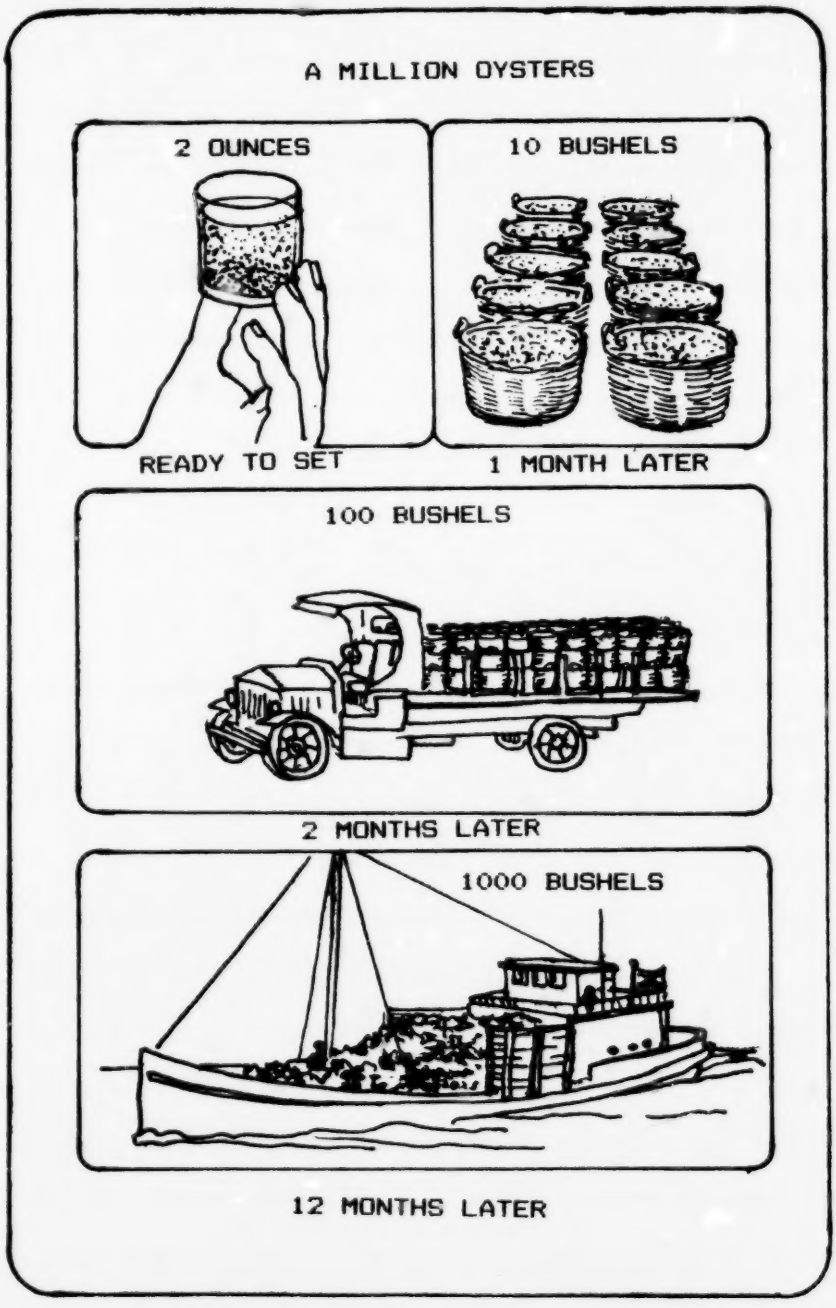
Problems with the necessary annual supply of seed is a major factor determining the success of commericial oyster operations in North America. The majority of British Columbia oyster growers obtain their seed from Pendrell Sound, B.C., the Provincial Shellfish Reserve. In Pendrell Sound a fairly predictable supply of seed is available annually, although every few years conditions are not conductive to adequate sets.

Before 1970 North American Pacific Coast growers were heavily dependent on oyster seed from Japan. This seed was collected in Japan

on oyster shells that were punched and strung on wires. Each wire was about six feet long and contained 100 or more shells. Ten such wires, or "ren", equalled a case and contained between 13,000 and 20,000 spat.

Since 1970 there has been increased dependence on the local natural seed collecting areas of Dabob Bay and Willapa Bay in Washington State and Pendrell Sound in British Columbia. However, because of the unreliability of natural seed sources and the dramatic price increase of Japanese seed, there has been an increased emphasis on hatchery techniques to produce oyster seed.

Developing commercial hatchery methods has been at least a one hundred year process. The first report of a sucessful artificial spawning of oysters was in 1879 when Brooks was able to develop "free-swimming" oyster larvae by stripping eggs and sperm from ripe adult oysters during their normal spawning season. Many more researchers attempted to rear larvae in their laboratories, but it was not until 1920 when Wells, in New York State, demonstrated successful rearing and setting



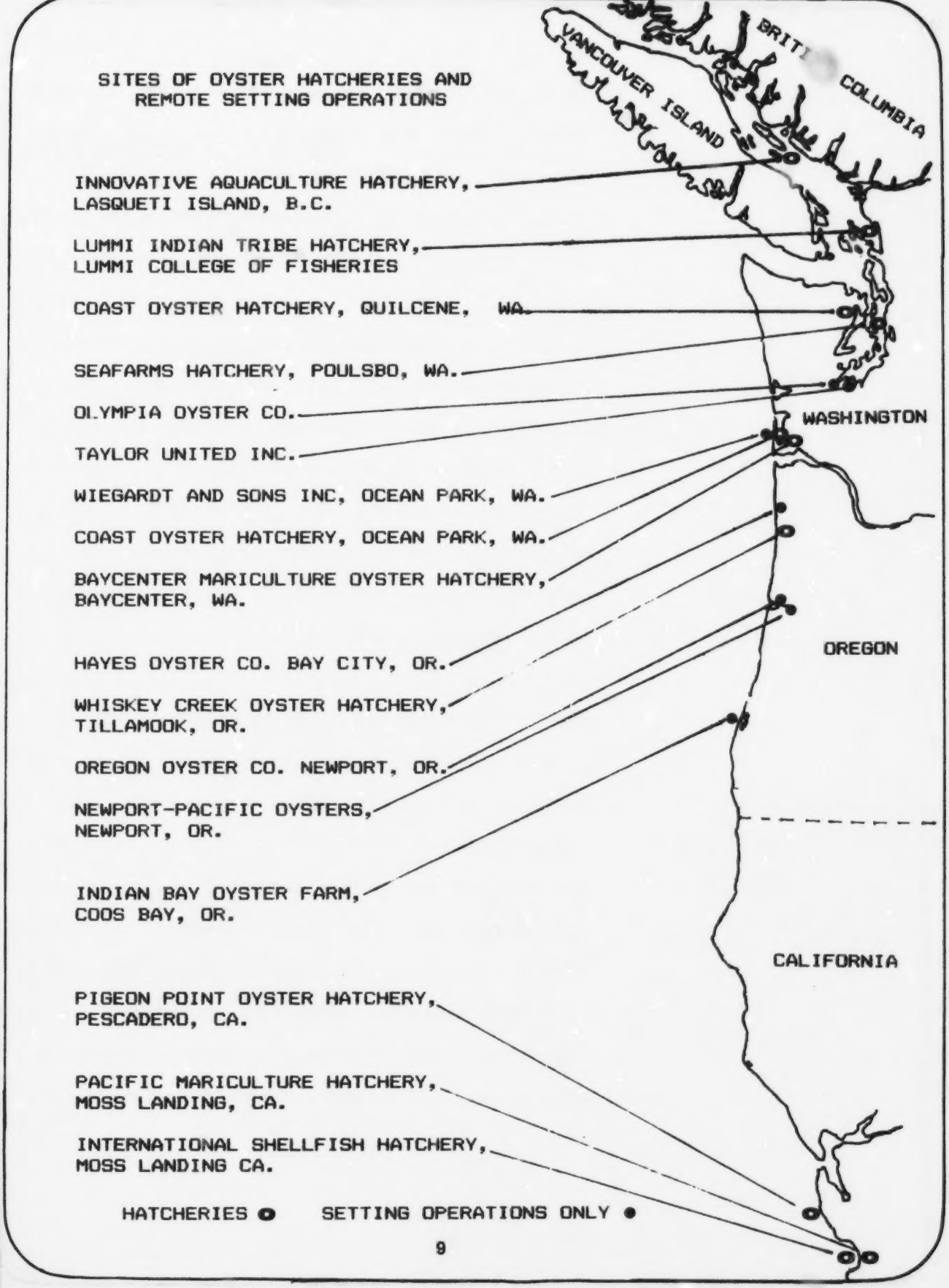
A MILLION OYSTERS. DRAMATIC SIZE COMPARISON. FROM W.F. WELLS (1920)

of oyster larvae and refined the techniques for hatchery operations.

In the past 50 years there has been much literature written on oyster hatcheries, for some examples: Wells (1920), Loosanoff and Davis (1963), Matthiessen and Toner (1966), Walne (1974), Breese and Malouf (1975), Dupuy, Windsor, and Sutton (1977).

The first oyster hatchery was built on the Pacific Coast in 1967 with the expectation of being able to compete with Japanese seed which was rapidly increasing in price; between 1957 and 1979 the price went from $6.00 to $45.00 per case F.O.B. Japan. The hatchery failed after a few years due to biological problems, but has since reopened and is now operating sucessfully.

During the 1970s other hatcheries were opened, but demand for hatchery seed was low because of consistent natural sets in Dabob Bay and Pendrell Sound. Then in 1975 and 1976 there were inadequate sets and the Washington growers turned to the hatcheries and requested that they produce the tens of thou-

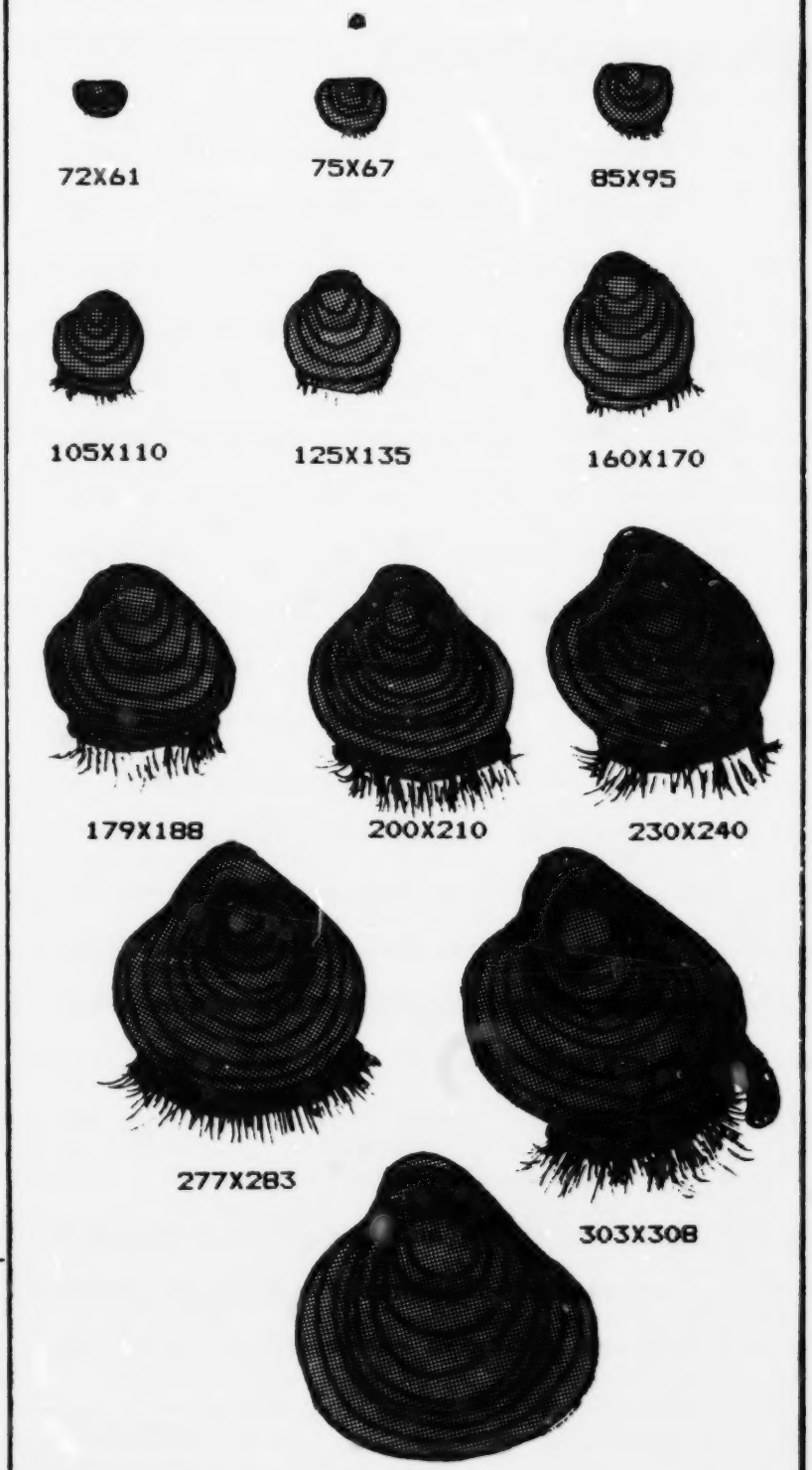

SITES OF OYSTER HATCHERIES AND
REMOTE SETTING OPERATIONS
INNOVATIVE AQUACULTURE HATCHERY,
LASQUETI ISLAND, B.C.
LUMMI INDIAN TRIBE HATCHERY,
LUMMI COLLEGE OF FISHERIES
COAST OYSTER HATCHERY, QUILCENE, WA.
SEAFARMS HATCHERY, POULSBO, WA.
OLYMPIA OYSTER CO.
TAYLOR UNITED INC.
WIEGARDT AND SONS INC, OCEAN PARK, WA.
COAST OYSTER HATCHERY, OCEAN PARK, WA.
BAYCENTER MARICULTURE OYSTER HATCHERY,
BAYCENTER, WA.
HAYES OYSTER CO. BAY CITY, OR.
WHISKEY CREEK OYSTER HATCHERY,
TILLAMOOK, OR.
OREGON OYSTER CO. NEWPORT, OR.
NEWPORT-PACIFIC OYSTERS,
NEWPORT, OR.
INDIAN BAY OYSTER FARM,
COOS BAY, OR.
PIGEON POINT OYSTER HATCHERY,
PESCADERO, CA.
PACIFIC MARICULTURE HATCHERY,
MOSS LANDING, CA.
INTERNATIONAL SHELLFISH HATCHERY,
MOSS LANDING CA.
HATCHERIES
SETTING OPERATIONS ONLY
VANCOUVER ISLAND
BRITI
COLUMBIA
WASHINGTON
OREGON
CALIFORNIA

sands of cases of seed that the growers needed, but the hatcheries were not in a position to produce so much in such a short time. The growers consequently had to turn again to Japan. Hatcheries have continued to exist on the Pacific Coast despite these problems (11 are now in operation), and they fall into basically three classes. Three primarily produce cultchless seed, depending for a large part on seed sales to Europe. The rest are part of organizations which mainly grow oysters, except for one which only produces eyed oyster larvae for growers to set at their own sites.

Over 50,000 cases of seed are now annually produced from hatchery reared larvae on the Pacific Coast. In 1981 there were 47,654 cases produced from natural sets in Dabob Bay and Willapa Bay in Washington State. At the time Japanese seed imports were at their highest volume, there were over 70,000 cases imported annually. In 1980, when there was a commericial set at Pendrell Sound, there was less than 13,000 cases produced there.

INTRODUCTION

The new development of setting the oyster larvae remotely from the hatchery holds encouraging prospects for British Columbia oyster growers. Setting the eyed-larvae on cultch can now be the activity of the grower, instead of the hatchery as in the past. Since many growers shuck their own oysters, they have a large supply of cultch available, allowing them to avoid the costs of hauling shell to and from hatcheries or the natural setting areas. In the past an independent hatchery that produced spat on cultch had to buy shell from the growers, set the larvae and then transport the set shell back to the grower. Expensive handling costs are likewise incurred by growers who take their shell into Pendrell or Dabob, etc. to catch the wild set. As fuel costs skyrocket, the expense of transporting larvae rather than cultch becomes more and more advantageous, not to mention the greater reliability of hatchery seed.



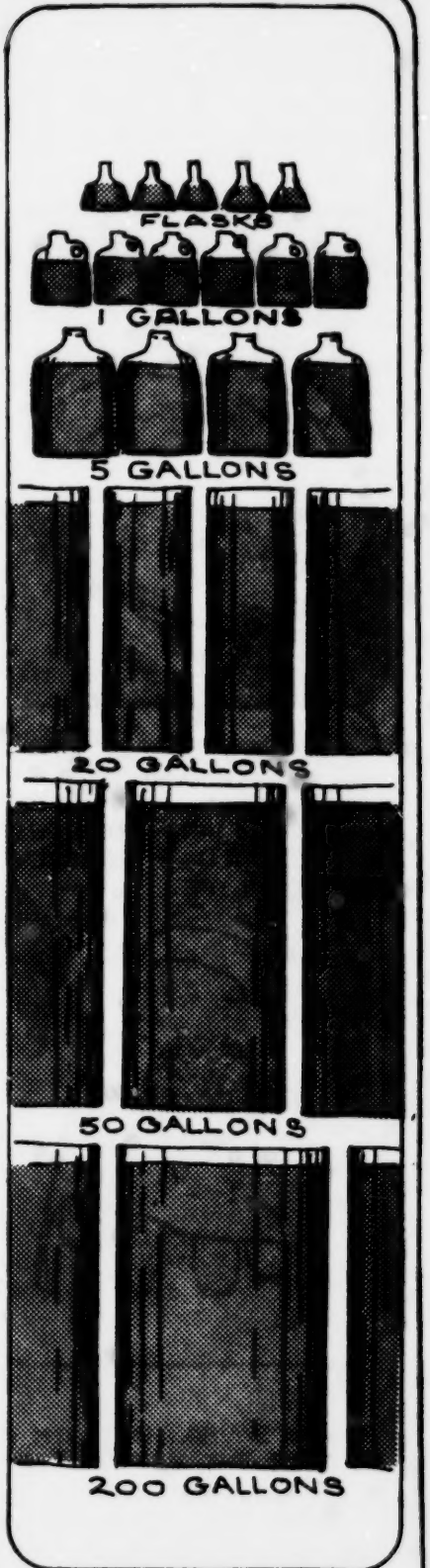
OYSTER LARVAE GROWTH PROGRESSION THROUGH THE SWIMMING STAGES OF DEVELOPMENT: (dimensions are in microns)

GENERAL HATCHERY AND SETTING METHODS

Ready-to-set larvae are available from several hatcheries on the Pacific Coast. They are generally produced and handled in the following manner: broodstock oysters are conditioned by holding in 18 C to 20 C water for three to four weeks. Spawning is then induced by raising or lowering the water temperature suddenly. If temperature shock does not cause spawning, reproductive products from a sacrificed oyster are added to the water, this chemically triggers the remaining oysters to spawn. Fertilization takes place externally and the larvae are grown in large tanks for three weeks in 25 C water.

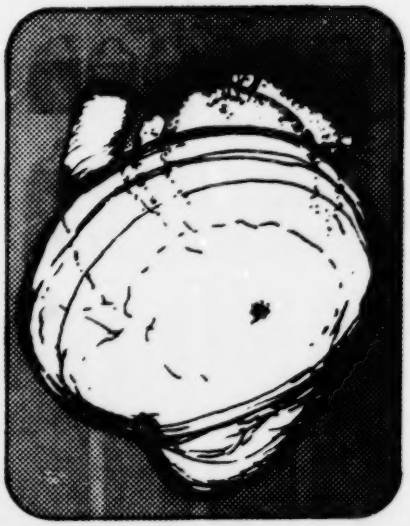
The larvae are fed unicellular algae less than 6 microns in diameter. The algae are continuously bloomed in different sized vessels, with each smaller vessel being the inoculant for a larger one. The algae is grown in a nutrient solution that contains nitrate, phosphate, trace metals and vitamins.

When the larvae are 20 days old, they measure 250 to 300 microns and develop an eye-



BATCH CULTURE OF ALGAE: SMALL CULTURES ARE USED AS INOCULENTS FOR LARGER CULTURES.

spot and a foot. It is at this point that growers can purchase and transport larvae to their setting tanks and seed cultch. Setting takes several days and the spat are held for a few days after they have set. Once the cultch is removed from this tank it is kept continuously immersed in seawater until the spat are a quarter inch in size, at which time they may be grown on the beach. These procedures are quite general; each shellfish hatchery uses different methods.



WHEN THE LARVAE ARE READY TO SET THEY HAVE A FOOT, AN EYESPOT, AND ARE EQUIPPED TO GLUE THEMSELVES DOWN FOR LIFE.

For remote setting the larvae are taken out of the hatchery rearing system and transported or stored damp at 5 C, but not submerged in water. They are usually wrapped in a wet nylon cloth. (Two and a half million eyed-larvae have the approximate volume of a golf ball.) This is then wrapped in wet paper towels and the bundle placed in an ice chest along with a blue-ice pack. Recent research has indicated that storing eyed-larvae in this way at 5 C for five to eight days before setting them appears to increase the percentage of attaching larvae and that the best temperature for setting such stored larvae is 25 C. (Barbara Carlson, 1981).

Normally, larvae are set within 24 hours of leaving the hatchery and at temperatures between 20 C and 30 C, with the results showing that the higher the temperature the better the set. In setting experiments maximum larval set occurred at temperatures between 25 - 30 C, with no larvae setting at 40 C. (Bruce Henderson,1981).

Setting usually starts as soon as the larvae are put into the setting tank with the cultch. Cultch is commonly oyster shell and should be aged and clean. Some growers add algae to the water during the set. After setting, the cultch is placed on the beach intertidally or hung subtidally.

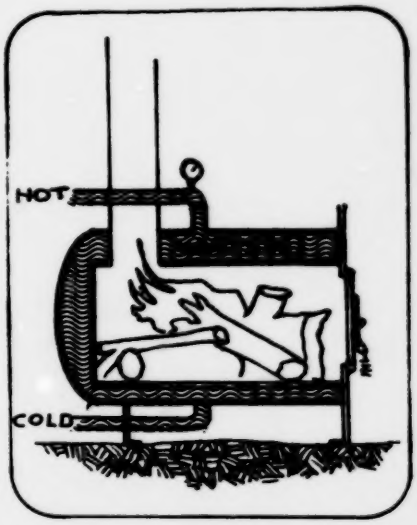
2.5 MILLION LARVAE are APPROXIMATELY THE SIZE OF A GOLF BALL AND LOOK LIKE SO MUCH WET SAND.

SURVEY OF DESIGNS, METHODS AND RESULTS

During the winter of 1981-1982 we interviewed many United States Pacific Coast oyster growers who had had several years experience setting eyed-larvae. They graciously showed us their operations and methods, answering our questions in detail. While no one system is the ultimate, by examining these varied successful operations we secured a good overview of what facilities and techniques work well (or are necessary) for the remote setting of eyed-larvae.

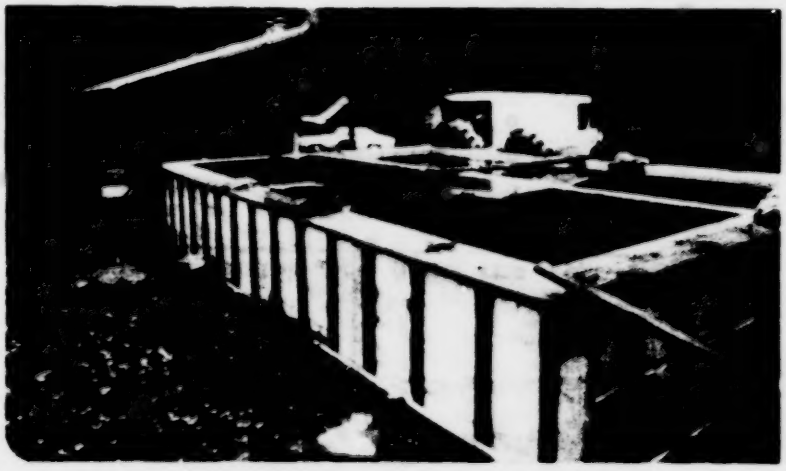
TAYLOR UNITED INC.

At TAYLOR UNITED INC. near Olympia, Washington, Mr. Justin Taylor showed us their two setting tanks. The tanks are each 30 feet long, 9 feet wide and 5 feet deep. They are constructed of concrete and insulated on the outside with styrofoam.

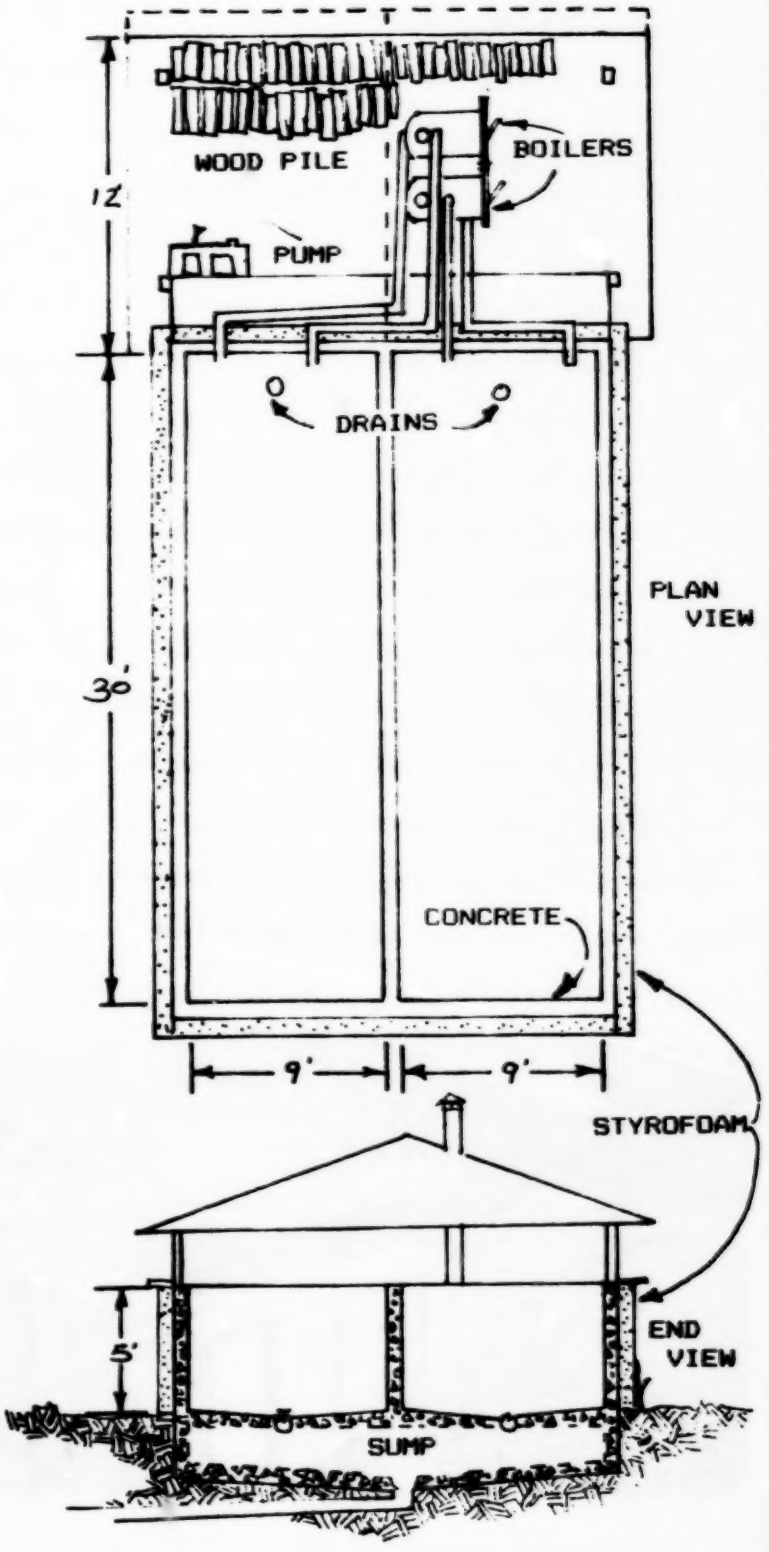


TAYLOR UNITED'S WOOD FIRED BOILER

The tanks are heated by two wood-fired boilers that heat fresh water which is circulated by a pump through ungalvanized steel pipes laid on the bottom of each setting tank. The water discharged from the boilers is 52 C, heating the setting tanks at a rate of one-half degree C per hour. Each boiler is connected to heat one tank, but there are cross-over valves to use both heaters on the same tank, if necesary.



VIEW OF TAYLOR UNITED'S TWIN SETTING TANKS WITH INSULATED WALLS. COVERED BOILER AREA IN BACKGROUND.



TAYLOR UNITED'S SETTING FACILITY: TANK WALLS ARE CONCRETE WITH THICK STYROFOAM INSULATION. FIREWOOD IS PILED ALONGSIDE THE BOILER AND THE BOILER AREA IS COVERED BY A METAL ROOF. A DRAINAGE SUMP IS AT THE END OF THE TANKS.

The aeration systems are powered by oil-less compressors that pump air into plastic pipes which have small holes drilled in them. The pipes are placed on the bottoms of the setting tanks.

The Taylors are setting their larvae on very old shell that has been run through a rotary drum, placed in cultch bags and then washed. These bags contain one 1/2 bushel and have approximately 160 to 175 pieces. They put 600 of these bags in each tank, and stack them 2 deep on 4 foot by 8 foot wood pallets. The pallets then are put into the tanks 3 deep by a fork lift.

The tanks are filled with unfiltered seawater, warmed to about 20 C to 24 C and constantly aerated. Eight million larvae are scattered into each tank while the water temperature is maintained for the next 3 to 5 days that is required for the larvae to set. During the setting period the water is partially changed to give the larvae natural algae.

Mr. Taylor said that usually about 20% of the

larvae set with an average 5 or 6 spat per shell; however, some shells collect as much as a couple of hundred. They do counts of spat on the top, middle and bottom of the tank; yet, he saw no pattern to the areas of light or heavy sets in the tanks.

The Taylors start setting the first of June as they want to avoid the barnacle set, which is around the middle of May. That way there is no chance of having the spat smothered by the fouling of barnacles. They then set each week through to the end of August. Mr. Taylor noted that they had problems with their latter sets and might not set as late in the fall next year.

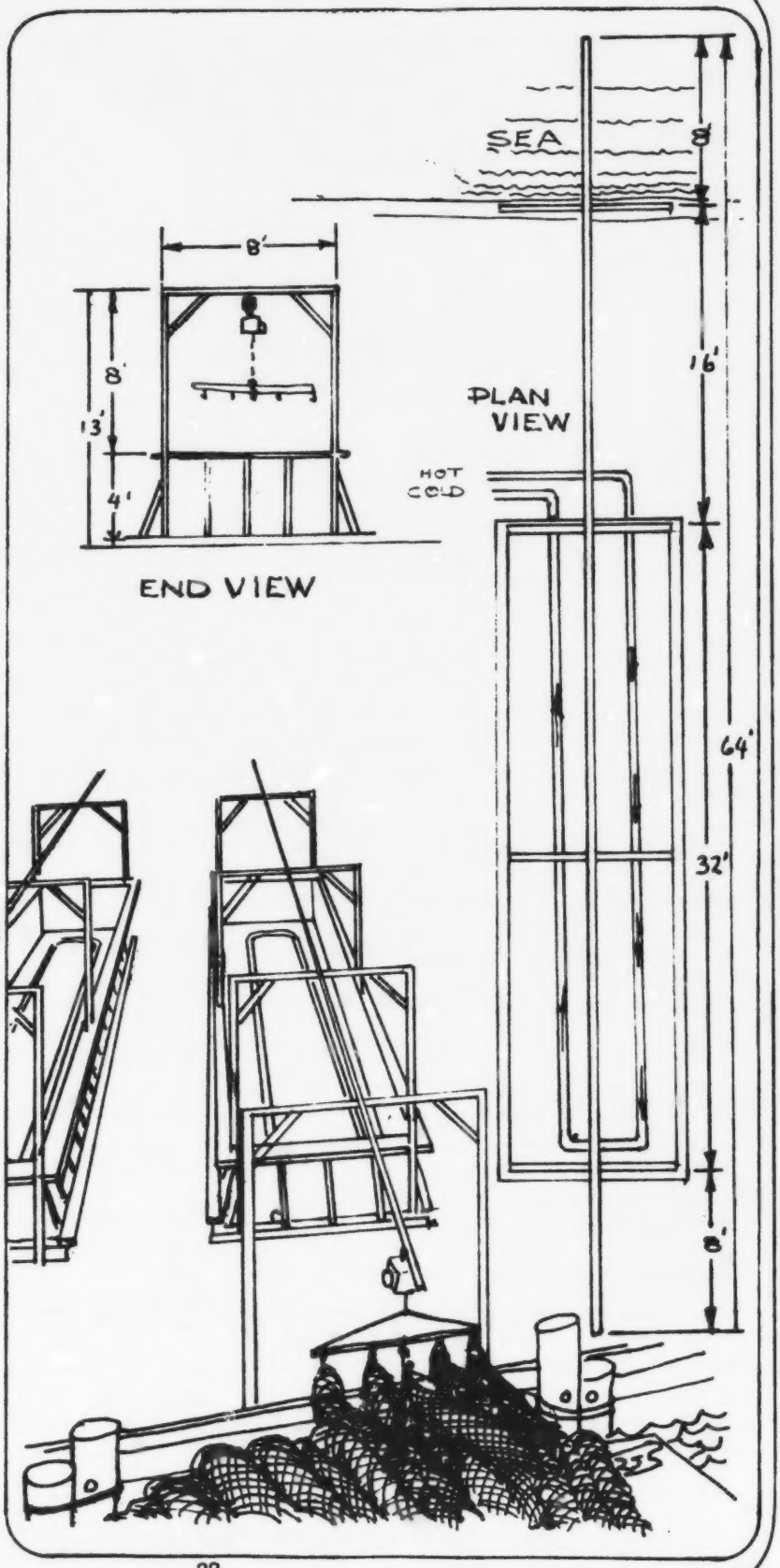
After the set cultch comes out of the setting tank, it is put on the beach intertidally. In that region there are problems with flat worms. Keeping the cultch intertidally consequently reduces this predation. The tanks are scrubbed out with water between sets.

The Taylors have done some experimenting with artificial cultch; in particular, cemented egg cartons and cemented veneer, but with

WOOD-FIRED BOILERS FOR HEATING SETTING TANKS. SUMP AREA IS AT LEFT. FRESH WATER IS CIRCULATED THROUGH THE BOILERS AND STEEL PIPES LAID ON THE BOTTOMS OF THE TANKS.

inconclusive results. It is interesting that they found cemented oyster shells attracted larvae better than either cemented egg cartons or cemented veneer.

Mr. Taylor said that he believes in the system of setting hatchery reared eyed-larvae, because of the reliability of a constant seed supply.



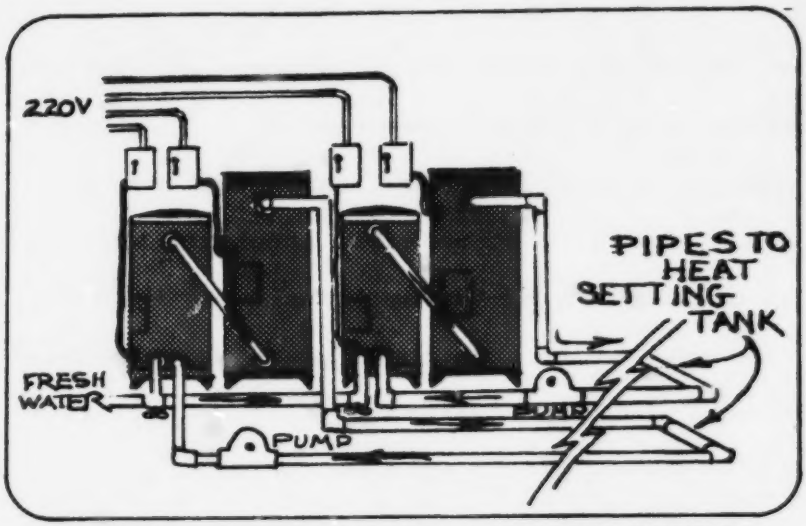
OLYMPIA OYSTER COMPANY'S SETTING SYSTEM.

OLYMPIA OYSTER COMPANY

At OLYMPIA OYSTER CO., located on Totten Inlet near Olympia, Washington, Mr. David McMillin explained about their setting system. He was most emphatic about the success of using the eyed-larvae technique. He said, "Because of it, in three years we will have three times the oysters to sell as we have now-- selling them will be our only problem. Seed uncertainties will never be a problem again."

OLYMPIA OYSTER CO. uses two tanks, each 32 feet long, 8 feet wide and 4 feet deep. They are constructed of plywood with fiberglass sprayed over the inside surface. Each tank is heated by two 4,000 watt domestic electric hot water heaters plumbed in series. Fresh

SETTING TANKS ARE AT RIGHT CENTER OF PHOTO AND CULTCH LOADING SET-UP IS AT LEFT CENTER. IN THE FOREGROUND ARE THE BLOCKS OF STYROFOAM THAT ARE INSERTED IN THE TOPS OF THE CULTCH BAGS.

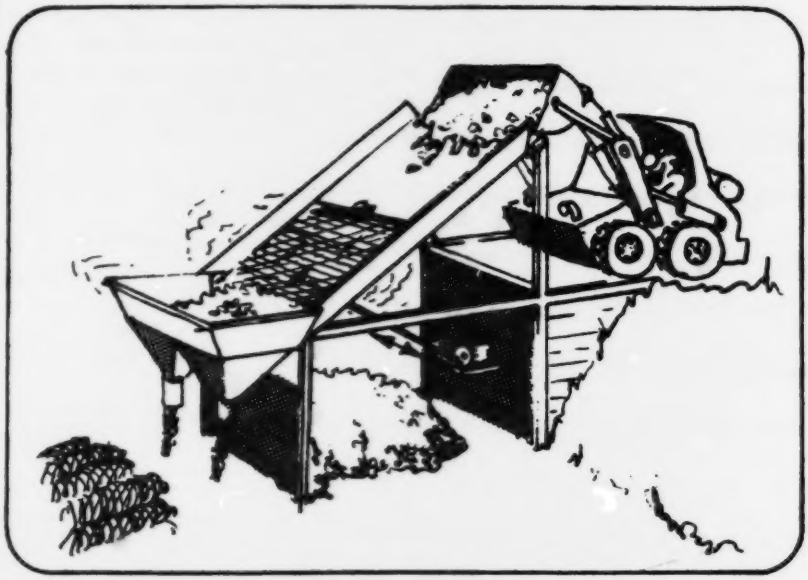


OLYMPIA OYSTER COMPANYS' HEATING SYSTEM: DOMESTIC HOTWATER TANKS HEAT THE FRESH WATER THAT CIRCULATES THROUGH PLASTIC PIPES ON THE BOTTOM OF THE SETTING TANKS.

water is pumped from the heaters through plastic pipes laid in the bottom of the setting tanks. The tanks are aerated by pipes with holes drilled in them running the length of the tank.

They put 500 twenty pound cultch-bags in each tank, fill the tanks with unfiltered seawater, raise the water temperature to 23 C and put 10 million larvae in each tank. The temperature is kept at 23 C for 3 days. Then the heat is turned off and raw seawater is pumped into the tank to feed the spat. The aeration is run continuously until the fifth day when the tanks are unloaded and the cultch removed.

Some of it is rafted and the rest is put intertidally on the beach. The cultch that is placed on the beach is on pallets with 24 bags to a pallet. The rafted cultch bags each have a block of styrofoam at one end large enough to float it and are secured by ropes inside of a floating frame. The bags are cut open when the spat starts to grow through the mesh, and the cultch is spread on the growing areas after the cultch shells are smashed in a breaking machine.



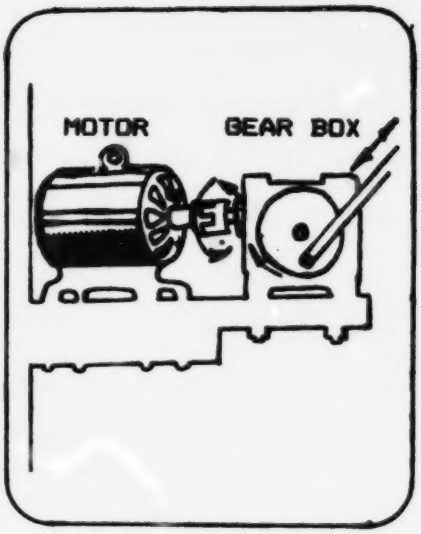
OLYMPIA OYSTER COMPANY CULTCH PREPARATION SETUP: OYSTER SHELLS ARE SLID ACROSS A SHAKER SCREEN AND END UP IN A HOPPER WITH BAGGING PIPES COMING OUT OF THE BOTTOM.

Mr. McMillin emphasized that clean shell is very important. "It should be bagged two years prior to setting," he said.

Above the setting tanks are overhead rails with electric hoists on them for unloading. The tanks are located adjacent to the water

in order that the cultch can be directly loaded from the tank to a scow at high tide.

Mr. McMillin doen't like his larvae to be refrigerated on the trip up from the hatchery. While he claims 20 C is optimum one shipment arrived at 26 C and there was no problem. He says, "Moisture control is the most important thing. The larvae just shouldn't be packed too wet or too dry."



OLYMPIA OYSTER COMPANY'S VIBRATOR FOR SHAKING SHELL CHIPS OUT OF THE CULTCH BEFORE IT IS BAGGED

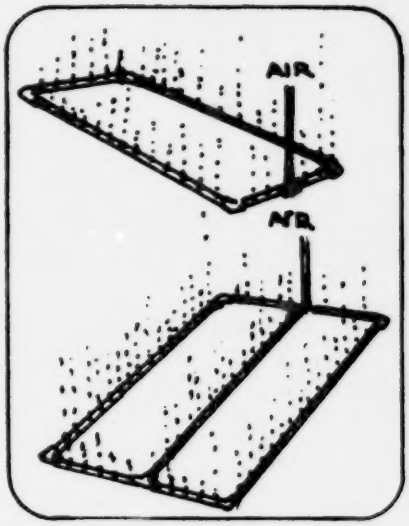
OLYMPIA OYSTER CO. sets larvae once a week from June through October. They find their results somewhat inconsistant. Some sets are as poor as 5 per shell; however, many are 30 to 40 per shell. The normal range is usually 15 to 400, though 20 per shell is preferred. Uniformity is felt to be proportional to circulation. Light doesn't appear to have any effect, aside from causing algae growth. They have done some research on artificial cultch and found that cemented surfaces take much more larvae to get the same intensity of set as shell.

Mr. McMillin told us of the first successful remote eyed-larvae transfer. OLYMPIA OYSTER CO. brought the larvae from Pigeon Point Hatchery in California, and set several bushels of oyster seed on shell.

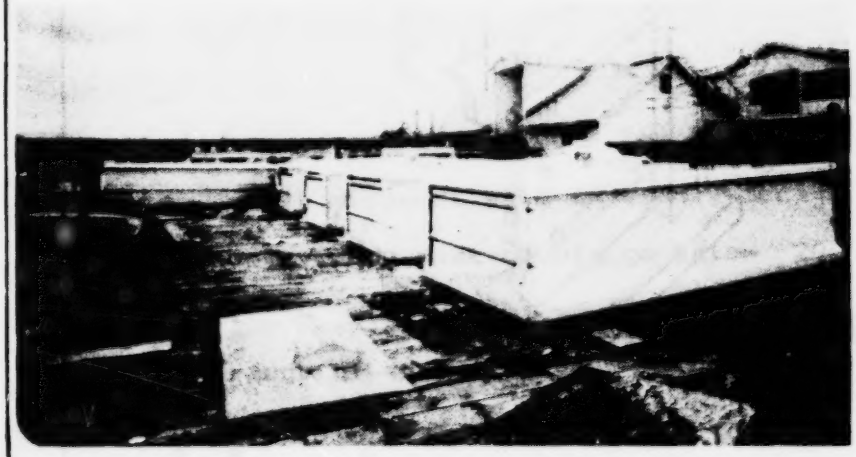
WIEGARDT AND SONS INC.

At Ocean Park, Washington on Willapa Bay, we visited Lee Wiegardt and Rich Bohn of WIEGARDT AND SONS INC. They have 6 setting tanks that are 16 feet long, 8 feet wide and 4 feet deep. The tanks are built out of 1 1/4 inch plywood with fiberglass coated over the inside and outside of the tank.

The tanks are heated with 18,000 watt quartz electric immersion heaters that are put directly in the seawater. The aeration system is driven by a 5 hp Roots blower that delivers air at 10 psi and the air is injected by three perforated plastic pipes running down the center of the tanks. The incoming seawater is filtered by a 10 micron GAF filter bag.

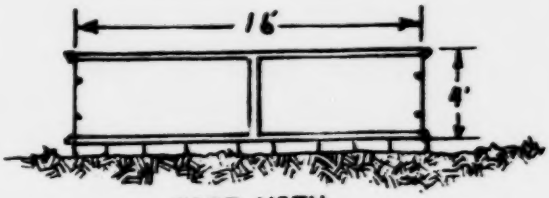


PLASTIC PIPE AERATION SYSTEM: SMALL HOLES ARE DRILLED IN THE PIPES TO GIVE EVEN AERATION SO THAT LARVAE ARE DISPERSED THROUGHOUT THE CULTCH.

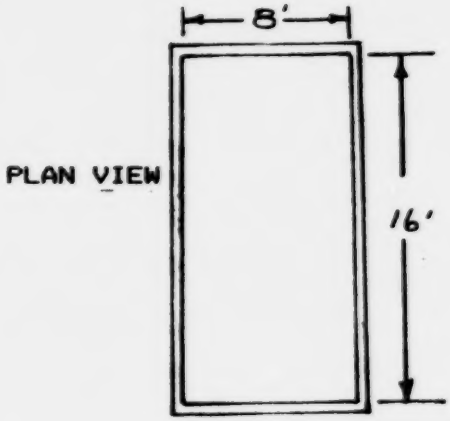


WIEGARDT'S SETTING TANKS ARE LOCATED ON THE PIER IN FRONT OF THE PROCESSING BUILDING.

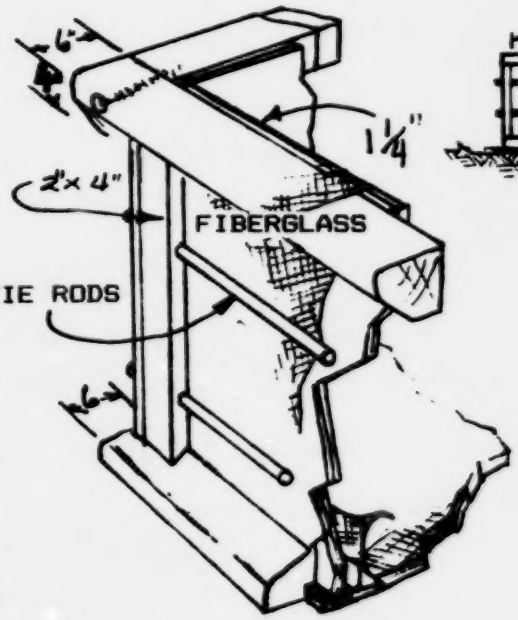
WIEGARDT'S PLYWOOD AND FIBERGLASS TANKS

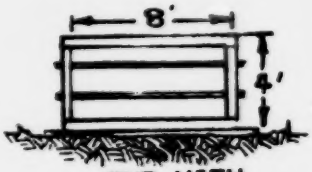


SIDE VIEW



PLAN VIEW





END VIEW

WIEGARDT AND SONS use two year old bagged shell for cultch, washed prior to loading into the setting tanks and packed tightly in the tanks. The setting water temperture is maintained at 21 C to 27 C depending on the B.O.D. level. The tanks hold 50,000 to 70,000 shells and 100 larvae per shell is put into the tank by a spoon on a pole.

Mr. Wiegardt says that the actual setting takes 1 to 3 days, but the cultch is kept in the tank for 5 to 6 days. They feed the spat 1,300 liters of algae per day. The algae species that they grow are Isochrysis galbana and Cyclotella nana Clone 3H. The set cultch is put on pallets on the beach after coming out of the tank. The Wiegardts operate their setting operation from the beginning of April through mid-September and in 1981 set 20,000 bags of shell.

Detailed records are kept of the setting results. Mr. Wiegardt said that only occasionally do average spat counts go below 20 per shell. A typical set would have the following range of spat counts:

GAF FILTER BAGS ARE A GOOD WAY TO FILTER INCOMING SEAWATER. (seam of bag should be turned to the inside)

EYED-LARVAE BEING DISPERSED AROUND THE TANK BY A SPOON ON A POLE

7.4% have 0-5 spat per shell
79% have over 11 spat per shell
53% have over 20 spat per shell
13% have over 61 spat per shell

They found that with dirty shell their average counts were 16 per shell and up to 44 with extra clean shell.

Mr. Wiegaredt has found that this remote setting system is actually cheaper than collecting the natural spat in Dabob Bay as he does not have the added cost of trucking and extra handling required for Dabob Bay. In the Willapa area there is a strong feeling that the Willapa oyster is genetically superior to that of the Dabob or Pendrell oyster so the hatchery uses Willapa broodstock.

It seems prophetic to the writers, that when a company the size of the entire B.C. oyster industry, that has been growing and selling oysters for over a hundred years and a manager that has been in the oyster seed business for over twenty years decide to depend entirely on the remote setting system, the dependability and economy of the system has been proven.

SEA FARMS INC.

SEA FARMS INC. was originally located at Poulsbo, Washington. Mr. Lee Hanson was the manager and chief biologist during that time and gave us the following report of their setting methods.

They had two cement tanks that were 20 feet long, 10 feet wide and 4 feet deep. Also they had 8 plywood tanks that were 8 feet by 8 feet and 4 feet deep. Mr. Hanson said that they put 200 bags in each of the cement tanks and that their bags had 500 pieces in them. The water was heated with an oil-fired boiler and Pyrex glass heat exchanger. The incoming water passed through a sand filter.

Prior to bagging, the shell was tumbled in a cement mixer, then through a shaker and was washed and bagged. The cultch was handled by a fork lift and loaded in and out of the tank by an overhead rail with a winch that could handle a sling with 20 bags hanging from it. After the cultch came out of the setting tank, it was taken out to a raft to grow, before being spread the on beaches.

The water was kept at 27 C and continuously aerated. As they felt that light had an effect on the set, they kept the cultch in darkness during setting. One hundred larvae per shell were added to the tank by placing the eyed-larvae in a bucket of setting tank water which was poured into the tank as they started to swim. The setting larvae and spat were fed algae. Mr. Hanson reported that they usually got 10% to 20% to set and normally had 20 per shell. The establishment operated year around.

SEA FARMS had to move from Poulsbo because of the pollutants that the Navy was accidentlly spilling into the water at the nearby torpedo station. They moved the operation to a floating barge on Hoods Canal and had so many problems securing permits to operate that they finally gave up being a hatchery and turned the barge into a shucking house.

LUMMI INDIAN TRIBAL HATCHERY

The Lummi Indian Tribe's oyster hatchery near Bellingham, Washington is now being run as part of the Lummi College of Fisheries. Mr. Alvin Cassimer gave us a tour of their impressive facilities, explaining their setting

THE LUMMI'S CULTCH IS HANDLED ON POLYETHYLENE PALLETS UNTIL AFTER IT HAS BEEN SET.

methods. The hatchery produces 300 million eyed-larvae per month and operates from March through September.

They are operating 5 cement setting tanks. Each is 32 feet long, 5 feet wide and 4 feet deep. The setting water comes out of the hatchery seawater system where it has been sand filtered and heated by two 1,500,000 BTU

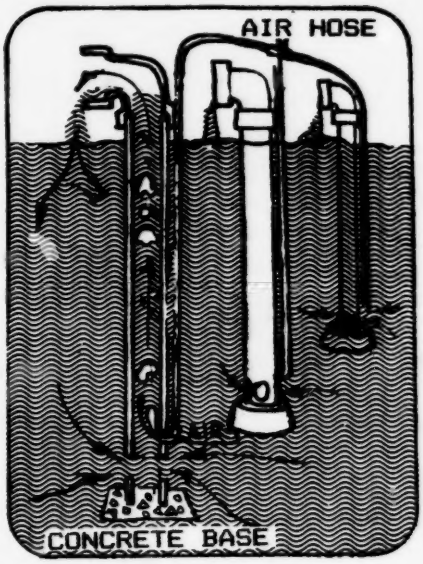
propane boilers. The setting is done at 25 C, although Mr. Cassimer remarked that 21 C or 22 C gets adequate survival also. The aeration is provided by six 2 inch air lifts in each tank. This method rapidly moves the water from the bottom of the tank to the top and shoots it across to the other side of the tank.

Overhead rails with winches load and unload the cultch efficiently. They put 147 cultch bags in each tank on polyethylene pallets. Mr. Cassimer said that they use two year old shell, running it through a vegetable washer that terminates in a hopper with pipes for bagging the shell. The vexar bags are 13 inch lay flat, four feet long with 500 shells in each. The converted vegetable washer

TWO VIEWS OF LUMMI CULTCH PREPARATION MACHINE, A CONVERTED VEGETABLE WASHER.

tumbles and sprays water on the shell, thus eliminating all the chips and shell powder.

They add 7 million eyed-larvae per tank by pouring them out of a 5 gallon bucket. Algae is added, although the setting only takes a day. Within 24 hours the set cultch is moved out to the raft area, which is located right in front of the tide gates to their lagoon. This gives the newly set spat maximum circulation for their first month; then they are moved to the beach.



LUMMI HATCHERY AIRLIFT SYSTEM: COMPRESSED AIR IS RELEASED NEAR THE BOTTOM OF THE TWO INCH PLASTIC PIPE FORCING A LARGE VOLUME OF WATER UP AS IT RISES. THE ELBOW AT THE TOP OF THE PIPE DIRECTS THE WATER ACROSS THE SURFACE OF THE TANK. THE WATER ENTERS THE TWO INCH PIPE THROUGH THE HOLES DRILLED IN IT JUST ABOVE THE CONCRETE BASE.

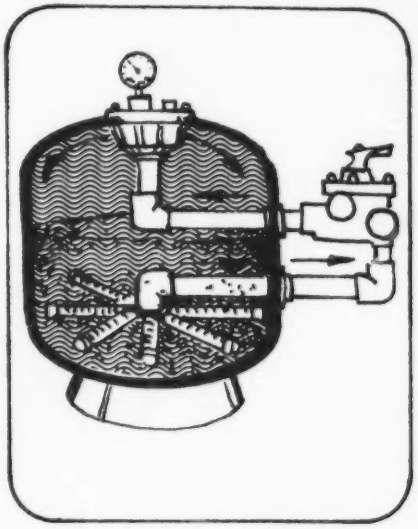
MR. CASSIMER EXPLAINED THE CULTCH HANDLING METHODS AND AERATION SYSTEM USED FOR SETTING. OVER HIS HEAD IS THE TRAVELLING I-BEAM USED FOR PLACING THE PALLET LOADS IN THE TANKS.

Mr. Cassimer said that they only figure on 10% of the larvae metamorphizing, but they get 15 to 20 per shell. Uniformity is a bit of a problem; the range is 5 to 200, with no apparent reason for the inconsistencies.

AFTER 24 HOURS IN THE SETTING TANK THE CULTCH IS MOVED TO THE HIGH CURRENT AREA IN FRONT OF THE LAGOON TIDE GATES TO GET FAST CROWTH. THEN IT IS LATER MOVED TO THE BEACH.

HAYES OYSTER CO.

Mr.Sam Hayes at HAYES OYSTER CO, Tillamook, Oregon, showed us the new addition that has been added to their processing building for setting eyed-larvae. Inside it is a 10 foot long fiberglass tank that is 8 feet wide and 4 feet deep. The seawater comes in through a sand filter and is heated with an electric boiler and glass heat exchanger. The aeration system is driven by a rotary blower.

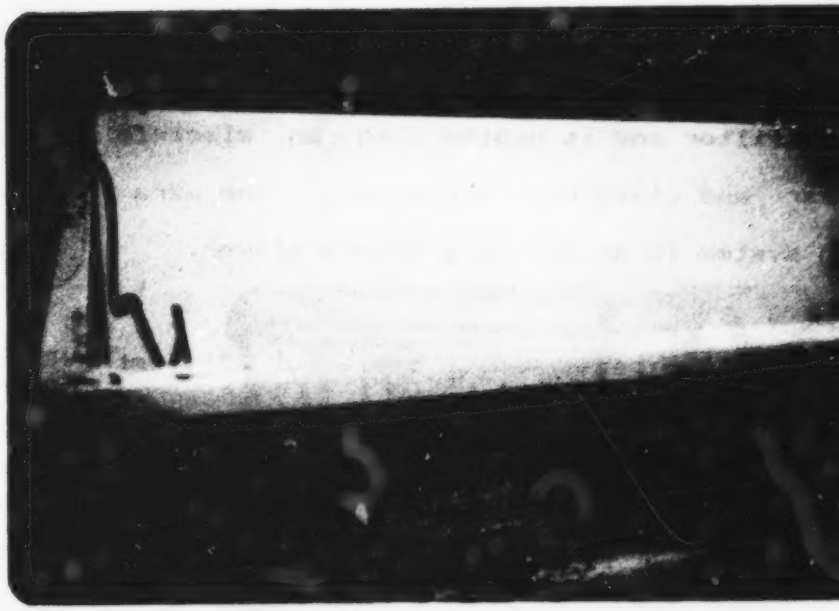


SAND FILTERS ARE COMMERICIALLY BUILT FOR SWIMMING POOLS. WATER COMES IN THE TOP, GOES THROUGH THE SAND AND OUT THROUGH THE BOTTOM MANIFOLD.

Their cultch bags, which are about 3 feet long, contain 300 pieces of shell. They load, by hand, 400 of these bags into the tank. The tank is filled with 27 C water and maintained above 21 C for the duration of the set, which usually takes 30 hours. The tanks are aerated constantly during this time. Four million larvae are put into the

THE WHITE BUILDING ON THE RIGHT CONTAINS HAYES' SETTING TANK.

tank which is kept covered during the set
No feed is given the larvae or spat durin
the setting operation.



COMMERCIALLY BUILT SETTING TANK USED BY HAYES.

The Hayeses start setting early in the seaso
and finish by the first of August. They fin
that the density of set averages 15 pe
shell; however, the sets are uneven. The
have a local environmental problem that give
poor survival of spat that is set after July

INDIAN BAY OYSTER FARMS

We talked to Mr. Mark Maring of INDIAN BAY OYSTER FARMS, which are located at Coos Bay, Oregon. They have 6 tanks, built out of 3/4 inch plywood with a fiberglass coating. The tanks are 8 feet long, 4 feet wide and 4 feet deep and are heated with 18,000 watt quartz electric immersion heaters.

They place 50 bags containing 220 shells in each tank. The tanks are constantly aerated and the water is maintained at 22 C to 26 C. One million larvae are put into each tank and the spat are held in the tank for one week. Next year they plan to grow algae to feed the larvae during this period.

They operate their setting system from April through September and are satisfied with the results. They usually get 20 spat per shell and figure that about 30% metamorphose.

OREGON OYSTER CO.

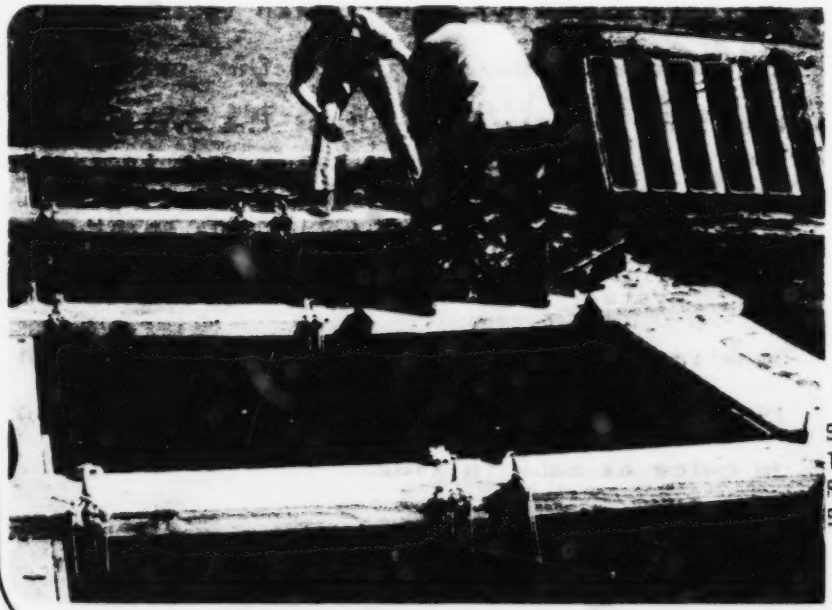
At OREGON OYSTER CO. on Yaquina Bay, Oregon we talked to Mr. LeRoy Whitney. Their setting tank is located alongside the shucking house and just above the high tide level. The

IN THE FOREGROUND IS THE SETTING TANK WITH AERATION PIPES ON THE BOTTOM. IN THE BACKGROUND ARE THE RAFTS THAT THE CULTCH TRAYS ARE SUSPENDED FROM AFTER THE SETTING IS FINISHED.

fiberglass setting tank, which was commercially molded in Portland, measures 10 feet by 8 feet and 4 feet deep. The seawater is heated by a propane-fired boiler that is located inside the shucking shed. The aeration system is run intermittently, one hour on and one hour off.

They use clean unbagged shells, placing them on 3 by 5 foot trays that are lowered into the tank filled with unfiltered 27 C water and 75 bushels of cultch. This temperture is maintained for the duration of the set which usually takes two days. They put 3 to 4 million larvae in the tank and estimate that over 50% of the larvae set on the shell, with spat counts of around 100 to 150 per shell. The larvae are not fed during the set. The spat are immediately moved to the rafts after setting.

Setting begins in May and continues through August. For some undetermined reason their last three sets were failures this year. However, they apparently aren't discouraged as they plan to continue their setting system next year.



SHELL IS PLACED LOOSE IN TRAYS THAT ARE HUNG BELOW RAFTS AFTER COMING OUT OF SETTING TANK.

NEWPORT-PACIFIC OYSTERS

At NEWPORT-PACIFIC OYSTERS near Newport, Oregon we talked to Mr. Ed Hickman, the foreman. They have 4 tanks that are 4 feet by 4 feet and 2 feet deep. The aeration system is driven by a vacuum cleaner blower. It is run intermittently, an hour on and an hour off.

The incoming seawater passes through a sand filter that removes everything larger than 200 microns. Shell cultch is put through an apple washer before it is put, unbagged, in the cultch tank, 40 bushels to each tank.

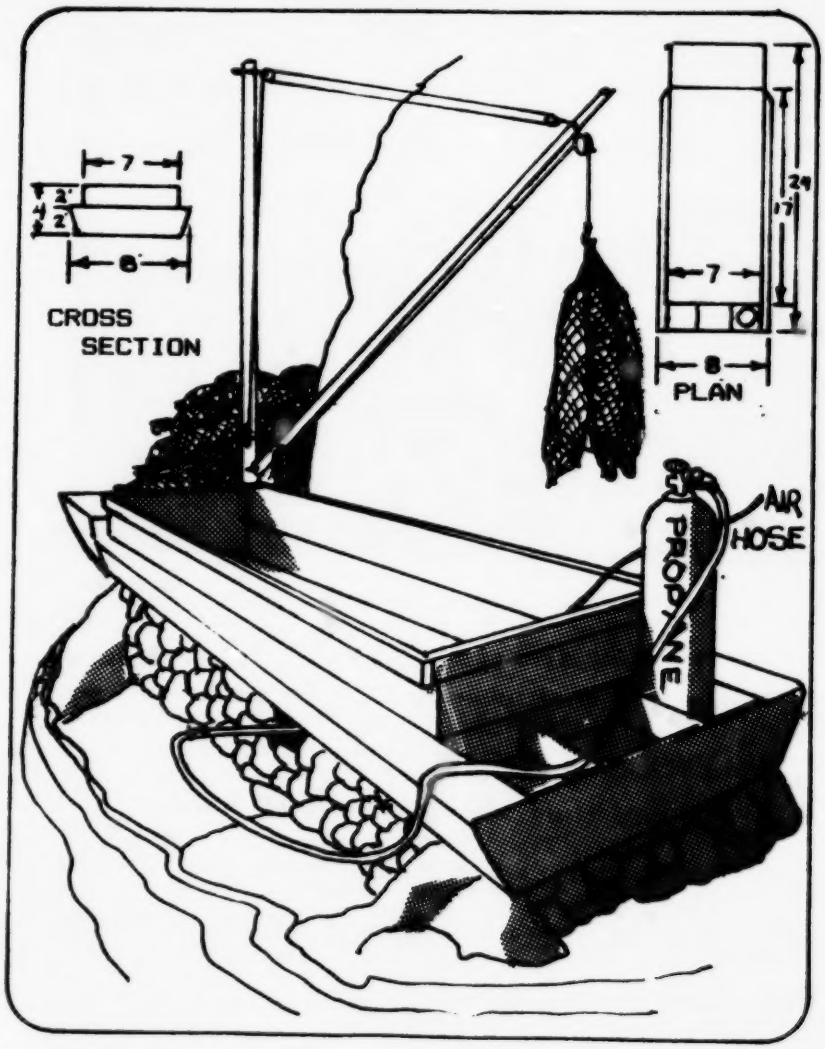
One million larvae are put into each tank and the temperture held for two days while the larvae are setting. The cultch is then moved out into the bay and put in the net cages that they use for grow-out of the oysters.

Mr. Hickman said that they operate the setting system from April through November. Sometimes they set 3 batches per week. In 1981 they set 150 million larvae and plan to do twice as many in 1982.

NEWPORT-PACIFIC'S BARGE ON WHICH SETTING TANKS ARE LOCATED.

He reports that over 50% of the larvae set and without any problem with uniformity. He pointed out they were getting a denser set than they desired. They preferred 7 per shell and were getting counts of 15 to 30 per shell.

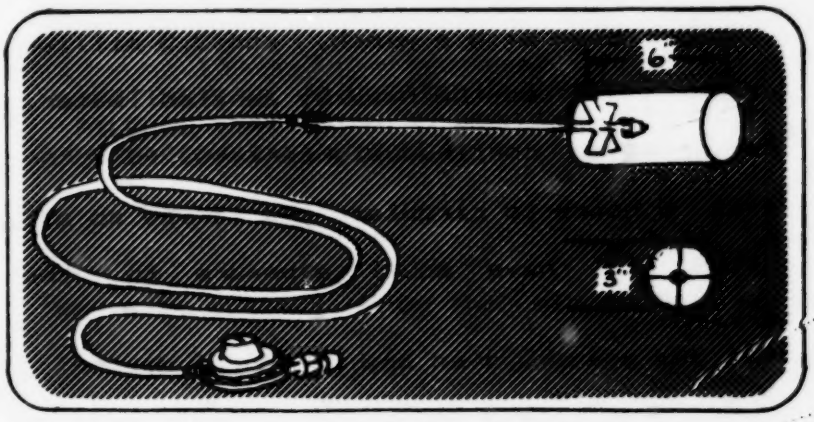
Next year they plan to build 4 larger tanks, 18 feet by 9 feet and 5 feet deep, which will be large enough to hold their grow-out cages. They expect this will reduce their handling time.



INNOVATIVE AQUACULTURE PRODUCTS' SETTING TANK FOR SHELL IS BUILT OUT OF A HERRING SKIFF AND USES A PROPANE TORCH UNDER IT TO HEAT THE WATER. OVER HEAD BOOM IS USED TO LOAD AND UNLOAD BAGGED CULTCH.

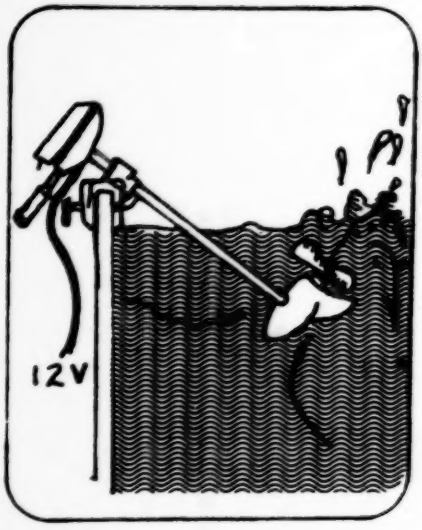
INNOVATIVE AQUACULTURE PRODUCTS, LTD.

Our own company, INNOVATIVE AQUACULTURE PRODUCTS,LTD. on Lasqueti Island, British Columbia, uses two setting tank systems: one used for setting on shell and the other for artificial cultch. The tank used for shell is 17 feet long, 7 feet wide and 4 feet deep. It is constructed of aluminium and plywood, finished on the inside with fiberglass. The tank is filled with 20 C water from the heat exchanger in the hatchery. Because the bottom half of the tank is aluminium, a propane burning torch can be placed under it to maintain the temperature of 20 C to 24 C during the set.



PROPANE FLAME THROWER TORCH

PROPANE FLAME THROWER TORCH DESIGNED FOR THAWING WATER LINES AND STUMP BURNING.



ELECTRIC OUTBOARD MOTOR FOR WATER MOVEMENT: TILTING UP THE MOTOR WILL MOVE THE WATER UP AND ACROSS THE TANK.

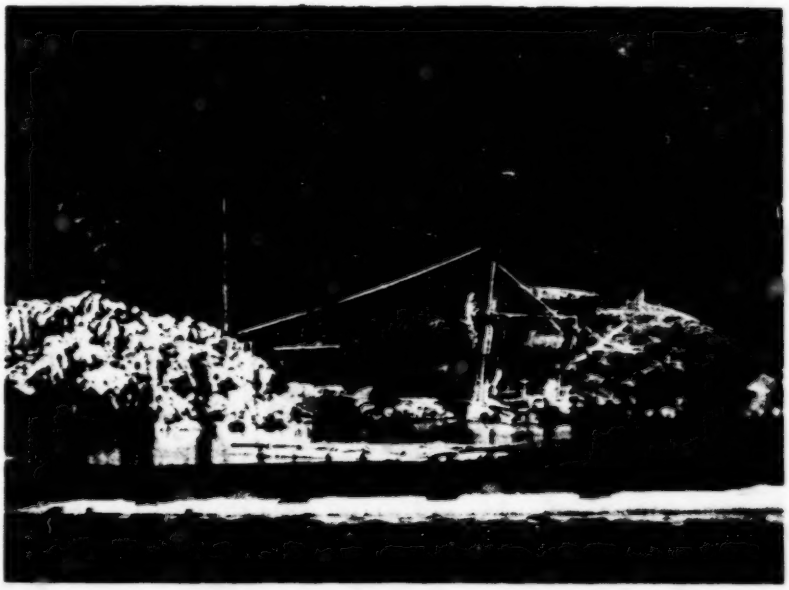
Seawater is filtered through GAF filter bags of a mesh size of 50 microns or smaller. The aeration system is powered by a General Motors automobile exhast system blower that is belt driven by a 1/3 hp electric motor. The air goes into a perforated plastic pipe placed down the center of the tank. The system is run intermittently during the set, which usually requires 3 days. We sometimes use an electric outboard to increase the water movement.

The bags of cultch are washed with water from a fire hose before being placed in the tank. They are usually 4 feet long, weigh 30 pounds and contain 120 large shells. Two hundred cultch bags are placed in the tank by a 25 foot boom with a winch, and 2.5 million larvae added to the heavily aerated water. The water is continuously aerated for the first 8 hours to circulate the larvae so all cultch will have equal exposure to the larvae.

The larvae are first put into a beaker of setting water and then slowly poured into the

tank as they begin to swim. The larvae are sometimes fed algae during the setting cycle. The algae are usually a mixture of the flagellates, Monochrysis lutheri and Isochrysis galbana, which we believe accelerates the setting.

POURING SWIMMING LARVAE INTO CULTCH TANK



SETTING TANK IS LOCATED ALONGSIDE CULTCH PILE SO THAT SWINGING BOOM CAN BE EASILY USED FOR LOADING TANK.

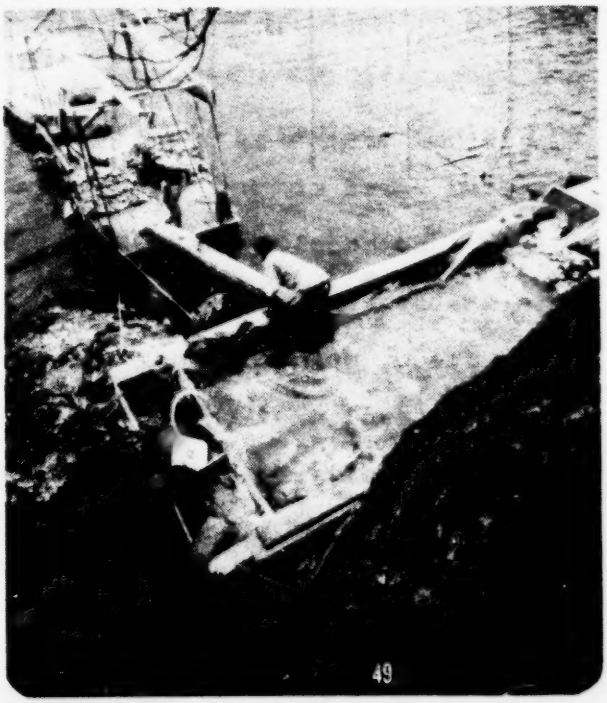
We set oysters from the middle of April through October, and have average set densities from 5 to 30 per shell, but usually around 15. It appears that only 10% to 25% of the larvae actually set. We are studying ways to improve this rate.

After the cultch has been in the tank for a week, it is moved out into the bay and the bags are hung under plastic floats for a month before the cultch is spread on the beach.

Our artificial cultch tank is a round fiber-glass tank with a diameter of 10 feet and is 4 feet deep. The artificial cultch that we have used over the past 6 years has been varied. We have not found any material that attracts larvae as well as oyster shell. However, when given no other option, larvae will set on almost any surface. We have found that the filler flats in which bulk eggs are packed, when coated with a cement slurry, make ideal spat collectors. They are cheap and break up easily after the spat reach a half inch. However, their draw back is that they get only 5% to 10% of the larvae to set on them; whereas with shell we usually expect around 20%. Any cemented cultch must be leached until the cement is chemically neutralizied, which normally takes several months. This is much more important for tank setting than it is for collecting natural set in a large body of water.

We took cultch into Pendrell Sound three consecutive years to compare the cost and results with our hatchery produced larvae. In 1978 there was an excellent set, better than we were doing in the hatchery. Then in 1979 we took in twice as much cultch and the set was so poor that it became smothered by a mussel set before it had a chance to grow, while the hatchery sets were excellent. The 1980 set was so poor that we never went back to Pendrell to take out our cultch as it wasn't worth the fuel that it would take to go back.

Although we have found using hatchery reared eyed-larvae is somewhat inconsistant from batch to batch, considering the system on an annual production output, it is much more reliable and efficient than natural seed collection.



UNLOADING SETTING TANK BY A SLIDE TO THE BARGE.

SUMMARY OF SETTING FACILITIES

PARAMETER	TAYLOR	OLYMPIA	WIEGARDT	SEA FARMS	LUMMI	HAYES	INDIAN BAY	OREGON OYSTER	NEWPORT-PACIFIC	I.A.P. LTD
NUMBER OF TANKS	2	2	6	10	5	1	6	1	4	2
CU. FT. OF EACH	1350	1024	512	800 256	640	320	128	320	32	467 314
TOTAL CU. FT.	2700	2048	3072	3648	3200	320	768	320	128	481
NO. SHELLS IN TANK	99000	100000	60000	80000	73500	12000	11000	24000	12000	24000
MATERIALS	CEMENT	P.W./F.G.	P.W/F.G.	CEMENT	CEMENT	F.G.	P.W./F.G.	F.G.		AL./F.G
ENERGY SOURCE	WOOD	ELEC.	ELEC.	OIL	PROPANE	ELEC.	ELEC.	PROPANE		PROPANE
WATER TREATMENT	NONE	NONE	FILTER	FILTER	FILTER	FILTER				FILTER
CELSIUS WATER TEMP.	20-23	23	21-27	27	25	21-27	22-26	27		20-24
NO. DAYS FOR SET	3-5	3	1-3		1	1-2				3-4
NO. LARVAE IN TANK	8 MILL.	10 MILL.	6 MILL.	8 MILL.	7 MILL.	4 MILL.	1 MILL.	3-4MILL.	1 MILL.	3 MILL.
FEED	NATURAL	NATURAL	ALGAE			NONE		NATURAL		ALGAE
DENSITY PER SHELL	5-10	5-40	20	20	15-20	15	20	100-150	15-30	5-30
PERCENT SET	20	20	20	10-20	10		30	50	50	10-30
DATES OF OPERATION	JE-SEPT	JE-OCT		ALL YEAR	MR-SEP	AP-AUG	AP-SEP	MAY-SEP	AP-NOV	AP-OCT

RECOMENDATIONS FOR REMOTE SETTING OPERATIONS IN BRITISH COLUMBIA

The environmental problems faced by mariculturists are almost always site specific. This is as true for grow-out operations as it is for hatcheries and the bridge between the two, setting operations. Our suggestions are based on our opinion of the general environmental conditions in British Columbia. Each grower planning to start a setting system will, of course, adapt and improve our suggestions to meet their own resources and needs.

SETTING TANK DESIGN AND CONSTRUCTION

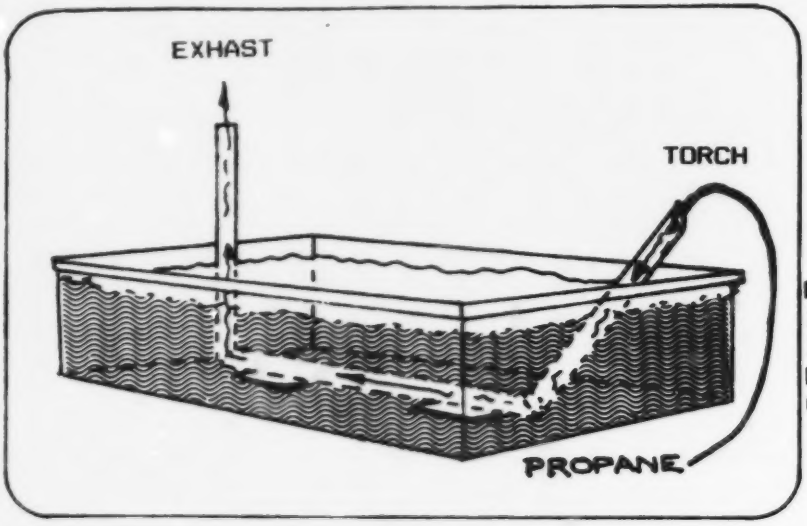
Probably the first consideration for a grower is the tank design. Larger tanks, of the 9,000 gallon size, are more efficient and economical in regards to loading, unloading and construction. There is less material required per gallon (or cultch bag) on a large tank; but since the stresses are much greater, smaller tanks can be built with lighter construction and take less bracing. Most hatcheries use average size tanks (two or three thousand gallons). This size tank

gives more control over the set and makes it is easier to evalute the results.

A tank 16 feet long, 8 feet wide, and 4 feet deep will hold about three hundred average size cultch bags. This size can be fairly easily constructed of plywood, braced with 2"X6" timbers and finished with fiberglass. All metals should be avoided in the seawater systems except cast iron and ungalvanized steel; even stainless steel has been reported to cause toxicity problems for oyster larvae. Some types or grades of aluminium or stainless steel may be used, but toxicity tests should be made before they are used. It is prudent to use fiberglass lined tanks and plastic plumbing in all seawater systems.

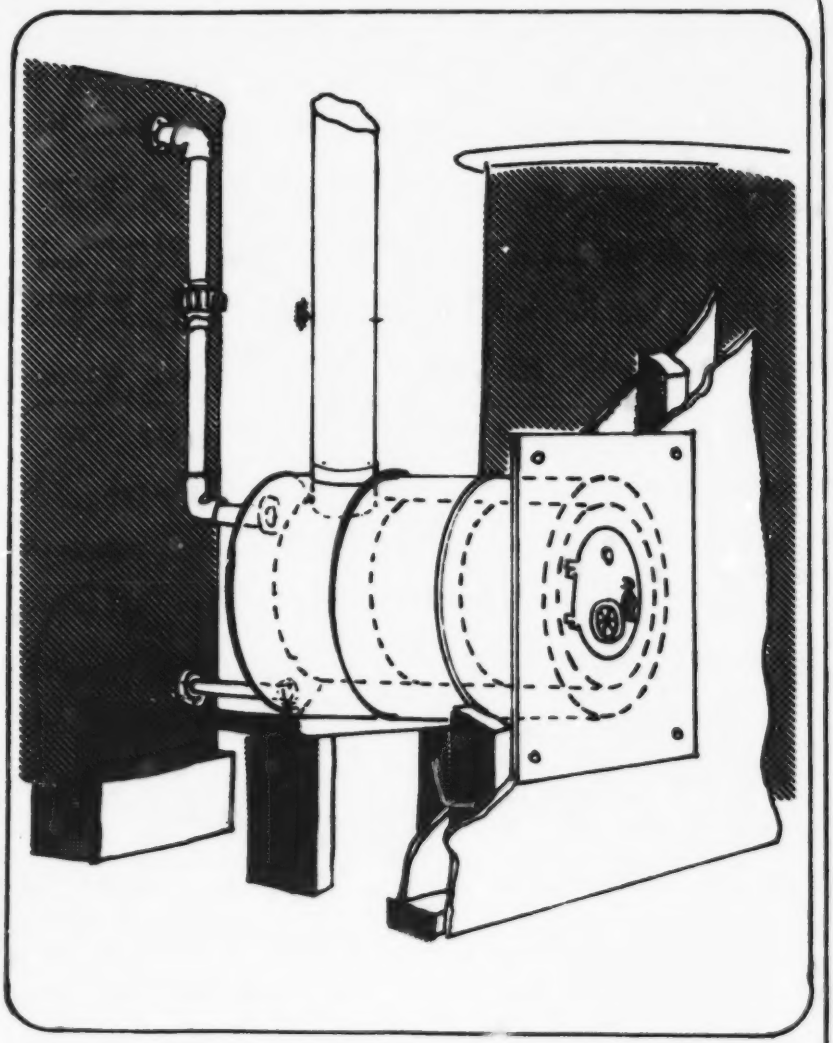
The methods of heating are dependent on the source of energy locally available. Electricity is the most automatic and trouble free, but is unavailable in many locations at the current necessary for the large electric heaters. Quartz sheathed electric immersion heaters are a simple and proven way to heat seawater electrically. Propane is the second most reliable energy source. A simple pro-

pane immersion heater can be constructed by putting a propane flame thrower torch inside a 3" or 4" ungalvanized steel pipe that has been formed or cut and welded into a horse-shoe shape. The rounded part is placed on the bottom of the tank with the ends extending above the surface of the water.



PROPANE FLAME THROWER IMMERSION HEATER: TORCH IS INSERTED IN ONE END; EXHAST COMES OUT THE OTHER.

The relative costs of various methods of heating should be considered when designing a setting system. Heating 3,000 gallons of water from an ambient seawater temperature of 16 C to the necessary larvae setting temperature of 24 C requires about 500,000 BTUs. We estimate the BTU rating of the mixture of fir and alder that we burn in our heater at 15,000,000 BTUs per cord. At the cost of $100 per cord the heating cost would be $3.33 to bring the tank up to 24 C.



WOOD FIRED BOILER CONSTRUCTED OUT OF 30 GALLON DRUM WELDED INSIDE A 45 GALLON DRUM. SPACE BETWEEN THE DRUMS BECOMES THE WATER JACKET FOR THE FIRE INSIDE THE 30 GALLON FIRE BOX.

The comparison of cost per BTU, using various fuels is as follows:

Wood @ $100. per cord =$100. for 15 mill. BTUs

Propane @ $.25 per liter =$160. for 15 mill. BTUs

No. 2 Oil @ $.37 per liter =$170. for 15 mill. BTUs

Electricity @ $.05 per KW =$250. for 15 mill. BTUs

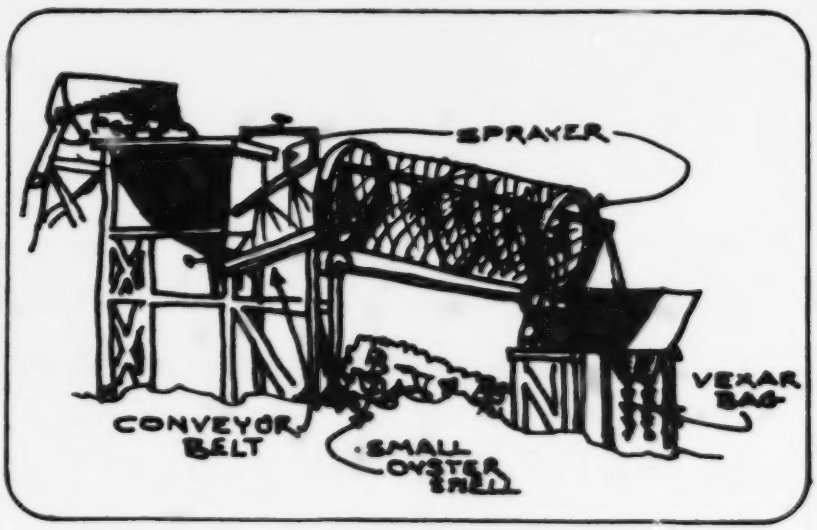
The cost to heat 3,000 gallons of water with propane is then $5.32, $5.66 with oil and $8.32 with electricty.

Aeration can be provided by any compressor, air pump or blower that does not produce an oil mist. (For example, do not use piston type paint sprayers which use petroleum oil in the crank case.) An efficient and inexpe-nsive blower is the type used on General Motors automobile exhast systems. These blowers are vane type and can be belt driven by a 1/3 hp or 1/2 hp electric motor or gas engine that is installed so that the pump will not pick up the exhast gases. Wrecking yards should sell these blowers for about $30. Oyster larvae do not require aeration; it is provided mainly for water movement to evenly distribute the the larvae throughout the cultch.

A mechanical method of loading and unloading the tank should be designed into the system. It is most efficient to be able to unload the tank by an overhead rail or davit directly onto the barge that will transport the cultch.

PREPARATION OF CULTCH

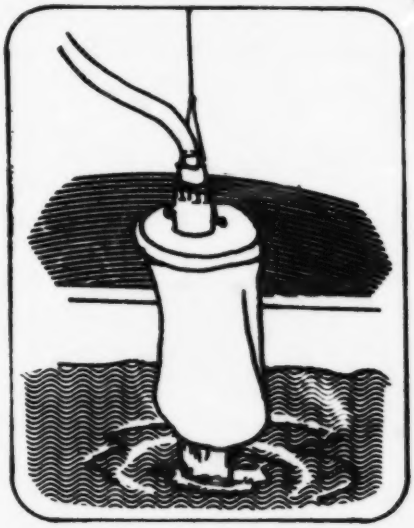
Cultch shells must be clean and aged for at least two years before being used. The shell chips and powder should be washed off prior to loading into the tank. If cement coated cultch is used, it should be leached until the cement no longer effects the PH of the water. Plastic cultch can be used, but as it does not have any attraction, a much larger quantity of larvae must be used to force the set. Larvae prefer to set on the bottoms of horizontal surfaces. Since artificial cultch appears to have a lower rate of sucessful metamorphosis, one should plan on adding twice as many larvae per sq.inch, as for shell, when adding the larvae to the water.



CULTCH CLEANING AND BAGGING SYSTEM. THE SHELL IS DUMPED IN HOPPER AT LEFT, MOVES UP CONVEYOR AND THROUGH TUMBLER WHILE WATER IS SPRAYED ON TO REMOVE CHIPS AND DUST. THE BAGGING HOPPER IS AT RIGHT.

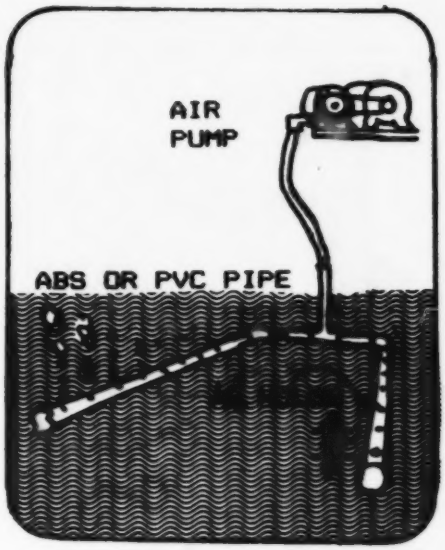
SETTING TANK ENVIRONMENTAL PARAMETERS

The seawater for setting should be filtered to 100 microns and maintained at 25 C while the larvae are swimming. A nonbreakable thermometer is most useful; we have found the plastic crystal types that are designed to stick on the surface of aquariums to be satisfactory. After the set has occured the temperature can be dropped and raw or filtered seawater pumped into the tank to feed the larvae. If algae is being cultured, it is usually added at a concentration the larvae can clear in a few hours. It has not yet been proven whether feeding with algae improves the setting density.



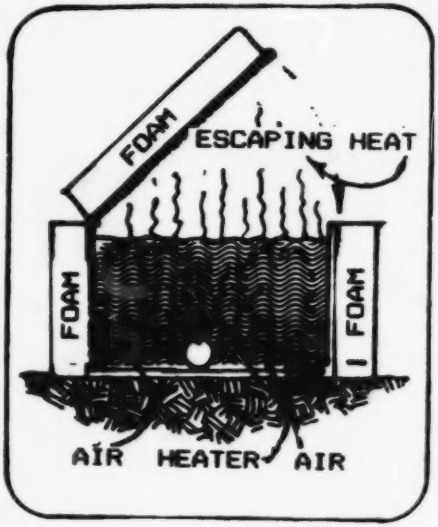
FILTER BAG FOR INCOMING WATER.

The water should be aerated at the rate of a rolling boil. Installing plastic pipes on the bottom of the tank with small holes drilled in them is a good method of distributing the air. Using several air lifts will improve the movement of water.



AIR DISTRIBUTION SYSTEM

During the time (usually two days) required to set the eyed-larvae, the 25 C water temperature must be maintained. After the set has occured the cultch should not be moved until



INSULATION OF TANK HOLDS IN HEAT

BONGO FILTER FOR WATER CHANGES: CONSTRUCTRED OF SIX INCH OR LARGER PVC PIPE AND NYLON SCREEN AND GLUED WITH PVC GLUE.

the spat starts to spread its shell out over the cultch surface. This will insure that it is well enough attached that it will not wash off. This usually takes three or four days. Light does not appear to have an effect on the quality of set. It is good practice however to cover the tank to reduce heat loss.

The number of larvae added to the tank depends on the density of set required. Since most growers seem to prefer 10 to 20 spat per shell, we recommend a larval density of 100 larvae per shell. A tank containing 300 cultch bags would take three and a half to four million larvae.

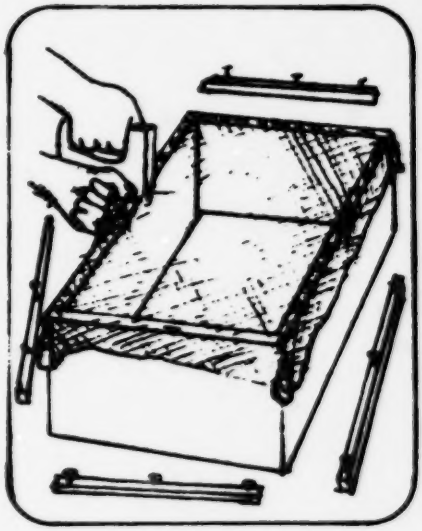
If a grower wishes to add more seawater or algae during the set, he probably will have to lower the level of the water in the setting tank. By draining the water out through a 200 micron (or less) nylon filter he can retain the larvae and dump the water. Whether or not algae needs to be grown, instead of merely changing the water, might be site specific and also dependent on the time of year.

One of the main advantages in setting your own eyed-larvae is that by setting it early

in the season it will be a whole growing year ahead of the natural set which normally occurs in August. However, July and August are the easiest months in which to set as heating is less of a problem.

We would advise growers who are contemplating using the eyed-larvae technique for the first time, to set up a medium sized tank to try out the system. If they produced sets every other week during the summer (keeping accurate records of the amount of larvae added to the tank, number of cultch bags and densities of set) they would by the end of the summer not only have produced a large quantity of seed, but also have a good idea of how the cost compares to their regular method of seed acquisition and consequently be able to determine knowledgeably their future methods of seed collection.

During the rest of the year when the tank is not being used for setting, it makes an ideal seawater system for holding live clams or crabs.



PLYWOOD BOX FILTER: CONSTRUCTED OF FOUR PIECES OF PLYWOOD, NYLON FILTER, STAPLES AND GLUE.

REFERENCES

Breese, W. P., and R. E. Malouf. 1975. Hatchery manual for the Pacific oyster. Oreg. State Univ. Sea Grant Publ. ORE54-4-75-002

Brooks, W. K. 1879. Abstract of observations upon artificial fertilization of oyster eggs and embryology of American oyster. Amer. J. Sci., New Haven, XVIII: 425-527.

Bruce, J. R., M. Knight, and M. W. Parke. 1940. The rearing of oyster larvae on an algal diet. Jour. Mar. Biol. Assoc. U. K., 24: 337-374.

Carlson, B. 1981. Settlement and subsequent survival of commercially-reared eyed larvae of the Pacific oyster, Crassostrea gigas. Unpublished paper presented at the 1981 PCOGA convention in Portland, Oregon.

Cole, H. A. 1937. Experiments in the breeding of oysters (Ostrea edulis) in tanks, with special reference to the food of the larvae and spat. Fish. Invest., London (Series 2) 15:1-28.

Davis, H. C., and R. R, Guillard 1958. Relative value of ten genera of micro-organisms as foods for oyster and clam larvae. U.S. Fish and Wildlife Service, Fish. Bull. 58: 293-304

Dupuy, J. L., and N. T. Windsor and C. E. Sutton 1977. Manual for design and operation of an oyster seed hatchery for the American oyster Crassostrea Virginica. Virginia Institute of Marine Science, Special Report No. 142

Galtsoff, P. S. 1964. The American oyster, Crassostrea virginica Gmelin. U.S. Fish and Wildlife Serv., Fish. Bull. 64: 1-480.

Henderson, B. 1981. Practical methods of handling and setting eyed pacific oyster larvae, Crassostrea gigas. Unpublished paper presented at 1981 PCOGA convention at Portland, Oregon.

Im, K. H., and R.D. Langmo. 1977. Hatchery produced Pacific oyster seed. Oreg. State Univ. Sea Grant Publ. ORESU-T-77-010

Loosanoff, V. L., and H. C. Davis. 1963. Rearing of bivalve mollusks. Advances in Marine Biology. 1:1-136.

Matthiessen, G. C., and R. C. Toner. 1966. Possible methods of improving the shellfish industry of Martha's Vineyard, Duke's County, Massachusetts. Marine Research Foundation, Inc.

Matthiessen, G. C. 1971. A review of oyster culture and the oyster industry in North America. Woods Hole Oceanogr. Inst., Woods Hole, Mass.

Quayle, D.B. 1969 Pacific oyster culture in British Columbia. Fish. Res. Bd. Can., Bull. 169. Ottawa.

Ukeles, R. 1969. Nutritional requirements in shellfish culture. Proceedings of the conference on artificial propagation of Cammerically Valuable shellfish--oysters, Edited by K. S. Price and D. L. Maurer. College of Marine Studies, University of Delaware, Newark, Delaware. pp. 43-64.

Walne, P. R. 1974. Culture of Bivalve Molluscs. Fishing News Books Ltd. England.

Wells, W. F. 1920 Growing oysters artificially. Conservationist. 3:151.

Westley, R. E. 1976. Oyster growing and culture in Washington State. Wash. Dep. Fish., Point Whitney Shellfish Lab.

POOR

QUALITY

ORIGINAL